

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

Signal Communication Coordination

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RELATED PATENT APPLICATIONS

This U.S. Non-provisional Application for Letters Patent claims the benefit of priority from (i) co-pending U.S. Provisional Application for Letters Patent Serial No. 60/423,702 (filed November 4, 2002) and (ii) co-pending U.S. Provisional Application for Letters Patent Serial No. 60/423,696 (filed November 4, 2002).

Specifically, this U.S. Non-provisional Application for Letters Patent claims the benefit of priority from, and hereby incorporates by reference herein the entire disclosure of, co-pending U.S. Provisional Application for Letters Patent Serial No. 60/423,702, filed November 4, 2002, and entitled "Synchronizing Media Access Control (MAC) Controllers".

Specifically, this U.S. Non-provisional Application for Letters Patent also claims the benefit of priority from, and hereby incorporates by reference herein the entire disclosure of, co-pending U.S. Provisional Application for Letters Patent Serial No. 60/423,696, filed November 4, 2002, and entitled "Multi-Mac Control Techniques".

TECHNICAL FIELD

This disclosure relates in general to the coordination of signals being communicated across one or more media and in particular, by way of example but not limitation, to preventing the thrashing of signals (e.g., packets) by coordinating

1 the release of downlink packets with the reception of uplink packets using a media
2 access control (MAC)-type mechanism.

3 4 **BACKGROUND**

5 So-called local area networks (LANs) have been proliferating to facilitate
6 communication since the 1970s. Certain LANs (e.g., those operating in
7 accordance with IEEE 802.3) have provided enhanced electronic communication
8 through wired media for decades. Since the late 1990s, LANs have expanded into
9 wireless media so that networks may be established without necessitating wire
10 connections between or among various network elements. Such LANs may
11 operate in accordance with IEEE 802.11 (e.g., 802.11(a), (b), (e), (g), (k), (n), etc.)
12 or other wireless network standards.

13 Although standard LAN protocols, such as Ethernet, may operate at fairly
14 high speeds with inexpensive connection hardware and may bring digital
15 networking to almost any computer, wireless LANs can often achieve the same
16 results more easily and/or at a lower cost. Furthermore, wireless LANs provide
17 increased mobility, flexibility, and spontaneity when setting up a network for two
18 or more devices.

19 In wireless communication generally, signals are sent from a transmitter to
20 a receiver using electromagnetic waves that emanate from an antenna. With a
21 standard wireless LAN, for example, these electromagnetic waves are sent equally
22 in all directions from a central point of emanation. Receiving devices positioned
23 at any angle with respect to the emanating point that are sufficiently close thereto
24 may participate in the wireless LAN. As a result, both infrastructure and ad-hoc
25 wireless networks may be established.

1 However, there are drawbacks to such standard omni-directional wireless
2 LANs or omni-directional wireless wide area networks (WANs). For example,
3 transmission range is limited, electromagnetic interference is unmanaged, network
4 congestion may grow ungoverned, and the likelihood of packet collisions is
5 unbounded. Furthermore, inefficiencies may multiply unchecked if two or more
6 centralized points of emanation happen to be positioned so as to have overlapping
7 coverage areas or are otherwise sufficiently proximate to one another.

8 Accordingly, there is a need for schemes and/or techniques for at least
9 partially ameliorating one or more of the above mentioned drawbacks and/or
10 inefficiencies.

11 12 **SUMMARY**

13 In an exemplary access station implementation, an access station for
14 wireless communications includes: a wireless input/output (I/O) unit that is
15 configured to establish multiple access points; and signal transmission/reception
16 coordination logic that is capable of ascertaining that an access point of the
17 multiple access points is receiving a signal and that is adapted to restrain at least
18 one other access point of the multiple access points from transmitting another
19 signal responsive to the ascertaining that the access point is receiving the signal.

20 In an exemplary system implementation, a system for wireless
21 communications includes: medium access controller coordination logic capable of
22 accepting multiple respective receive indicators from multiple respective baseband
23 units; the medium access controller coordination logic adapted to combine the
24 multiple respective receive indicators to produce multiple constructive receive
25 indicators, each constructive receive indicator of the multiple constructive receive

1 indicators indicating that one or more respective baseband units of the multiple
2 respective baseband units is receiving a signal; the medium access controller
3 coordination logic further adapted to provide the multiple constructive receive
4 indicators to multiple medium access controllers.

5 In an exemplary method implementation, a method includes: monitoring
6 multiple respective indicators acquired from multiple respective baseband units;
7 detecting whether at least one respective indicator of the multiple respective
8 indicators is affirmatively indicating that a signal is being received; and if so,
9 providing at least one instruction to at least two medium access controllers of
10 multiple respective medium access controllers, the at least one instruction
11 restraining the at least two medium access controllers from causing a transmission.

12 13 **BRIEF DESCRIPTION OF THE DRAWINGS**

14 The same numbers are used throughout the drawings to reference like
15 and/or corresponding aspects, features, and components.

16 FIG. 1 is an exemplary general wireless communications environment.

17 FIG. 2 is an exemplary wireless LAN/WAN communications environment
18 that includes an access station, a wireless input/output (I/O) unit, an antenna array,
19 and multiple communication beams.

20 FIG. 3 illustrates an exemplary set of communication beams that emanate
21 from an antenna array as shown in FIG. 2.

22 FIG. 4 illustrates an exemplary access station that establishes multiple
23 access points and includes signal transmission/reception coordination logic.

1 FIG. 5 is a flow diagram that illustrates an exemplary method for using an
2 access station having signal transmission/reception coordination logic for multiple
3 access points.

4 FIG. 6 illustrates an exemplary access station that includes multiple
5 components such as medium access controllers (MACs), baseband (BB) units, and
6 MAC coordinator logic.

7 FIG. 7 is a flow diagram that illustrates an exemplary method for using
8 MAC coordinator logic with multiple MACs and associated multiple BB units.

9 FIG. 8 illustrates another exemplary access station that includes multiple
10 components such as MACs, BB units, and MAC coordinator logic.

11 FIG. 9 is a flow diagram that illustrates another exemplary method for using
12 MAC coordinator logic with multiple MACs and associated multiple BB units.

13 FIG. 10 illustrates an exemplary implementation of and environment for
14 signal transmission/reception coordination logic.

15 FIG. 11 illustrates a first exemplary multiple access station environment
16 that includes signal transmission/reception coordination logic.

17 FIG. 12 illustrates an exemplary multiple access station environment that
18 includes MAC coordinator logic.

19 FIG. 13 illustrates a second exemplary multiple access station environment
20 that includes signal transmission/reception coordination logic.

21
22 **DETAILED DESCRIPTION**

23 FIG. 1 is an exemplary general wireless communications environment 100.
24 Wireless communications environment 100 is representative generally of many
25 different types of wireless communications environments, including but not

1 limited to those pertaining to wireless personal area networks (PANs) (e.g., Wi-
2 Media, IEEE 802.15, etc.) or wireless local area networks (LANs) (e.g., Wifi) or
3 wide area networks (WANs) (e.g., Wi-Fi, WiMax, etc.) technology, cellular
4 technology, trunking technology, and so forth.

5 In wireless communications environment 100, an access station 102 is in
6 wireless communication with remote clients 104(1), 104(2) ... 104(N) via wireless
7 communications or communication links 106(1), 106(2) ... 106(N), respectively.
8 Although not required, access station 102 is typically fixed, and remote clients 104
9 are typically mobile. Also, although only three remote clients 104 are shown,
10 access station 102 may be in wireless communication with many such remote
11 clients 104 via uplink wireless communications 106 transmitted from remote
12 clients 104 to access station 102 and via downlink wireless communications 106
13 transmitted from access station 102 to remote clients 104.

14 With respect to a so-called Wi-Fi wireless communications system, for
15 example, access station 102 and/or remote clients 104 may operate in accordance
16 with any IEEE 802.11 or similar standard. With respect to a cellular system, for
17 example, access station 102 and/or remote clients 104 may operate in accordance
18 with any analog or digital standard, including but not limited to those using time
19 division/demand multiple access (TDMA), code division multiple access
20 (CDMA), spread spectrum, some combination thereof, or any other such
21 technology.

22 Access station 102 may be, for example, a nexus point, a trunking radio, a
23 base station, a Wi-Fi switch, an access point, some combination and/or derivative
24 thereof, and so forth. Remote clients 104 may be, for example, a hand-held
25 device, a desktop or laptop computer, an expansion card or similar that is coupled

1 to a desktop or laptop computer, a personal digital assistant (PDA), a mobile
2 phone, a vehicle having a wireless communication device, a tablet or hand/palm-
3 sized computer, a portable inventory-related scanning device, any device capable
4 of processing generally, some combination thereof, and so forth. Remote clients
5 104 may operate in accordance with any standardized and/or specialized
6 technology that is compatible with the operation of access station 102.

7 FIG. 2 is an exemplary wireless LAN/WAN communications environment
8 200 that includes an access station 102, a wireless input/output (I/O) unit 206, an
9 antenna array 208, and multiple communication beams 202. Wireless LAN/WAN
10 communications environment 200 may operate in accordance with, for example, a
11 Wi-Fi-compatible or similar standard. Thus, in such an implementation,
12 exemplary access station 102 may operate in accordance with a Wi-Fi-compatible
13 or similar standard. Access station 102 is coupled to an Ethernet backbone 204.
14 Access station 102, especially because it is illustrated as being directly coupled to
15 Ethernet backbone 204 without an intervening external Ethernet router or switch,
16 may itself be considered a Wi-Fi switch.

17 Access station 102 includes wireless I/O unit 206. Wireless I/O unit 206
18 includes an antenna array 208 that is implemented as two or more antennas, and
19 optionally as a phased array of antennas. Wireless I/O unit 206 is capable of
20 transmitting and/or receiving (i.e., transceiving) signals (e.g., wireless
21 communication(s) 106 (of FIG. 1)) via antenna array 208. These wireless
22 communication(s) 106 are transmitted to and received from (i.e., transceived with
23 respect to) a remote client 104 (also of FIG. 1). These signals may be transceived
24 directionally with respect to one or more particular communication beams 202.
25

1 In wireless communication, signals may be sent from a transmitter to a
2 receiver using electromagnetic waves that emanate from one or more antennas as
3 focused in one or more desired directions, which contrasts with omni-directional
4 transmission. When the electromagnetic waves are focused in a desired direction,
5 the pattern formed by the electromagnetic wave is termed a “beam” or “beam
6 pattern.” The production and/or application of such electromagnetic beams is
7 typically referred to as “beamforming.”

8 Beamforming may provide a number of benefits such as greater range
9 and/or coverage per unit of transmitted power, improved resistance to interference,
10 increased immunity to the deleterious effects of multipath transmission signals,
11 and so forth. Beamforming can be achieved using any of a number of active and
12 passive beamformers. Exemplary beamformers are described further below with
13 reference to FIG. 6.

14 By using such a beamformer along with antenna array 208, multiple
15 communication beams 202(1), 202(2) ... 202(N) may be produced by wireless I/O
16 unit 206. Although three beams 202(1, 2, N) are illustrated with three antennas of
17 antenna array 208, it should be understood that the multiple antennas of antenna
18 array 208 work in conjunction with each other to produce the multiple beams
19 202(1, 2 ... N). An exemplary set of communication beam patterns is described
20 further below with reference to FIG. 3.

21 FIG. 3 illustrates an exemplary set of communication beams 202 that
22 emanate from an antenna array 208 as shown in FIG. 2. In a described
23 implementation, antenna array 208 includes sixteen antennas 208(0, 1 ... 14, and
24 15) (not explicitly shown in FIG. 2). From the sixteen antennas 208(0 ... 15),
25 sixteen different communication beams 202(0), 202(1) ... 202(14), and 202(15)

1 are formed as the wireless signals emanating from antennas 208 add and subtract
2 from each other during electromagnetic propagation. It should be noted that the
3 exemplary set of communication beams 202 are a pictorial representation and that
4 the illustrated shapes do not necessarily bear any relationship to the actual shape(s)
5 of beam(s) which may include a main beam and several side lobes (e.g., with fixed
6 beam forming) or an arbitrary shape of coverage (e.g., with adaptive beam
7 forming).

8 Communication beams 202(1) ... 202(15) spread out symmetrically from
9 the central communication beam 202(0). The narrowest beam is the central beam
10 202(0), and the beams become wider as they spread outward from the center. For
11 example, beam 202(15) is slightly wider than beam 202(0), and beam 202(5) is
12 wider than beam 202(15). Also, beam 202(10) is wider still than beam 202(5). It
13 should be understood that the set of communication beam patterns illustrated in
14 FIG. 3 are exemplary only and that other communication beam pattern sets may
15 differ in width, shape, number, angular coverage, and so forth. By way of
16 example only, an access station may alternatively utilize six beams (that are
17 emanating from an antenna array having eight elements), three beams, and so
18 forth.

19 Due to real-world effects of the interactions between and among the
20 wireless signals as they emanate from antenna array 208 (e.g., assuming a linear
21 antenna array in a described implementation), communication beam 202(8) is
22 degenerate such that its beam pattern is formed on both sides of antenna array 208.
23 These real-world effects also account for the increasing widths of the other beams
24 202(1 ... 7) and 202(15 ... 9) as they spread outward from central beam 202(0).
25 In fact, in a described implementation, communication beams 202(7) and 202(9)

1 are too wide for efficient and productive use. Hence, communication beams
2 202(7), 202(8), and 202(9) are not utilized in a described implementation. Such an
3 implementation that utilizes thirteen communication beams 202 (e.g., beams 202(0
4 ... 6) and beams 202(10 ... 15)) is described further below with reference to FIG.
5 8.

6 FIG. 4 illustrates an exemplary access station 102 that establishes multiple
7 access points 402 and includes signal transmission/reception coordination logic
8 404. As illustrated, access station 102 includes a wireless I/O unit 206. Wireless
9 I/O unit 206 includes or is associated with signal transmission/reception
10 coordination logic 404. Such logic may be implemented as hardware, software,
11 firmware, some combination thereof, and so forth.

12 In a described implementation, wireless I/O unit 206 establishes two or
13 more access points 402, such as multiple access points 402(1), 402(2) ... 402(N).
14 Each access point of the multiple access points 402 may correspond to, for
15 example, an individual access point in accordance with an IEEE 802.11-based
16 standard. Additionally, a wireless coverage area or region for each respective
17 access point 402 of the multiple access points 402 may correspond to, for
18 example, a respective communication beam 202 of multiple communication beams
19 202 (as shown in FIGS. 2 and 3).

20 Although communication signals directed into (or obtained from) different
21 access points 402 may be targeted at particular/specific coverage areas, bleedover
22 between access points 402 can occur. For example, a downlink signal
23 transmission for access point 402(2) can destroy an uplink signal reception for
24 access point 402(1). Signal transmission/reception coordination logic 404
25

1 coordinates uplink and downlink signals across (e.g., between and/or among)
2 different access points 402.

3 In operation, access station 102 establishes multiple co-located access
4 points 402 using wireless I/O unit 206. Generally, signal transmission/reception
5 coordination logic 404 coordinates uplink signal receptions and downlink signal
6 transmissions across different access points 402 so as to avoid or at least reduce
7 the frequency at which downlink signals are transmitted at a first access point
8 402(y) while uplink signals are being received at a second access point 402(x).

9 Specifically, signal transmission/reception coordination logic 404 is
10 adapted to monitor the multiple access points 402(1 ... N) to ascertain when a
11 signal is being received. When an access point 402(w) is ascertained to be
12 receiving a signal, signal transmission/reception coordination logic 404 is capable
13 of restraining (e.g., limiting, preventing, delaying, etc.) the transmission of signals
14 on the other access points 402(1 ... w-1, w+1 ... N). It should be noted that "w"
15 can be equal to 1 or N and that the other access points 402 reduce to access points
16 402(2 ... N) and 402(1 ... N-1), respectively.

17 Exemplary techniques for ascertaining whether a signal is being received
18 and for restraining the transmission of signals are described further below. The
19 monitoring, ascertaining, and restraining of signals can be based on and/or
20 responsive to a myriad of factors. For example, the signals can be coordinated
21 (e.g., analyzed and controlled) based on a per-channel basis. Such exemplary
22 factors are also described further below.

23 FIG. 5 is a flow diagram 500 that illustrates an exemplary method for using
24 an access station having signal transmission/reception coordination logic for
25 multiple access points. Flow diagram 500 includes three (3) blocks 502-506. The

1 actions of flow diagram 500 may be performed, for example, by an access station
2 (e.g., an access station 102 of FIG. 4).

3 At block 502, multiple access points are monitored. For example, access
4 points 402(1 ... N) may be monitored by signal transmission/reception
5 coordination logic 404 (e.g., to detect signal reception). At block 504, it is
6 ascertained that an access point of the multiple monitored access points is
7 receiving a signal. For example, it may be ascertained by signal
8 transmission/reception coordination logic 404 that an access point 402(1) of
9 multiple access points 402(1 ... N) is receiving a signal via a wireless I/O unit
10 206.

11 At block 506, the other access points of the multiple monitored access
12 points are restrained from transmitting a signal. For example, signal
13 transmission/reception coordination logic 404 may restrain access points 402(2 ...
14 N) from transmitting a signal. In a described implementation, signal
15 transmission/reception coordination logic 404 may restrain access points 402(2 ...
16 N) from transmitting signals until access point 402(1) ceases receiving the signal.

17 With reference again to FIG. 4, one access point 402 (and/or
18 communication beam 202) may operate on a different channel from that of another
19 access point 402 (and/or communication beam 202). If the different channels are
20 adjacent and/or not sufficiently-well defined, it may be beneficial to restrain
21 transmission on a first channel with a first access point 402 even when receiving a
22 wireless communication on a second different channel with a second access point
23 402. In another exemplary implementation for different channel situations, signal
24 transmission/reception coordination logic 404 may restrain transmission on one
25 channel on the basis of reception on another channel with an ongoing transmission

1 on a third channel to prevent (e.g., inter-modulation) distortion to the signals being
2 communicated in the wireless system.

3 FIG. 6 illustrates an exemplary access station 102 that includes multiple
4 components such as medium access controllers (MACs) 604, baseband (BB) units
5 608, and MAC coordinator logic 606. As illustrated, access station 102 also
6 includes an Ethernet switch and/or router 602, radio frequency (RF) parts 610, a
7 beamformer 612, and antenna array 208. A wireless I/O unit 206 (e.g., as
8 illustrated in FIGS. 2 and 4) may correspond to MACs 604, MAC coordinator
9 logic 606, BB units 608, and RF parts 610. Such a wireless I/O unit 206 may also
10 optionally include one or more of Ethernet switch/router 602, beamformer 612,
11 and antenna array 208.

12 In a described implementation, antenna array 208 is coupled to beamformer
13 612. Beamformer 612 is coupled to multiple RF parts 610(1), 610(2) ... 610(N).
14 Respective multiple RF parts 610(1), 610(2) ... 610(N) are coupled to respective
15 multiple BB units 608(1), 608(2) ... 608(N). On the other hand, Ethernet
16 switch/router 602 is coupled to multiple MACs 604(1), 604(2) ... 604(N). Both of
17 the multiple BB units 608(1, 2 ... N) and the multiple MACs 604(1, 2 ... N) are
18 coupled to MAC coordinator logic 606.

19 In operation generally, each respective MAC 604(1, 2 ... N) is associated
20 with a respective BB unit 608(1, 2 ... N). Although not specifically shown in FIG.
21 6, each respective MAC 604 may also be in direct communication with each of the
22 respective associated BB units 608. MAC coordinator logic 606 is configured to
23 coordinate the activities of the multiple MACs 604 (e.g., as a multi-MAC
24 controller (MMC)) with regard to at least one non-associated respective BB unit
25 608. For example, MAC coordinator logic 606 may forward an instruction to

1 MAC 604(1) responsive, at least partly, to an indicator provided from BB unit
2 608(2). MAC coordinator logic 606 may be implemented as hardware, software,
3 firmware, some combination thereof, and so forth.

4 In operation specifically, for a described implementation, Ethernet
5 switch/router 602 is coupled to Ethernet backbone 204 (of FIG. 2). Ethernet
6 switch/router 602 is capable of relaying incoming packets from Ethernet backbone
7 204 to the appropriate MAC 604 to which they correspond. Ethernet switch/router
8 602 is also capable of relaying outgoing packets from the multiple MACs 604 to
9 Ethernet backbone 204. Ethernet switch/router 602 may be implemented using,
10 for example, a general purpose central processing unit (CPU) and memory. The
11 CPU and memory can handle layer-2 Internet protocol (IP) responsibilities, flow
12 control, and so forth. When receiving packets from Ethernet backbone 204,
13 Ethernet switch/router 602 looks up the destination port for the destination MAC
14 604 address. In this manner, an Ethernet switch and/or router 602 may be realized
15 using software (or hardware, firmware, some combination thereof, etc.).

16 Antenna array 208 may be implemented as a phased array of antennas
17 generally. Beamformer 612, in conjunction with antenna array 208, forms
18 multiple beams such as communication beams 202 (of FIGS. 2 and 3).
19 Beamformer 612 may be implemented as an active or passive beamformer.
20 Examples of such active and passive beamformers include a tuned vector
21 modulator (multiplier), a Butler matrix, a Rotman or other lens, a canonical
22 beamformer, a lumped-element beamformer with static or variable inductors and
23 capacitors, and so forth. Alternatively, communication beams may be formed
24 using full adaptive beamforming.
25

1 Generally, beamformer 612 may include multiple ports for connecting to
2 antenna array 208 and multiple ports for connecting to the multiple RF parts 610.
3 One or more active components (e.g., a power amplifier (PA), a low-noise
4 amplifier (LNA), etc.) may also be coupled to the multiple ports on the antenna
5 array side of beamformer 612. Thus, antenna array 208 may be directly or
6 indirectly coupled to beamformer 612.

7 Specifically, beamformer 612 may include at least “N” ports for each of the
8 multiple RF parts 610(1, 2 ... N), but it may include more. In a described
9 implementation, each communication beam 202 emanating from antenna array
10 208 corresponds to an RF part 610. Each RF part 610 may be implemented as, for
11 example, a transmit and/or receive signal processor operating at radio frequencies.
12 Each RF part 610 may operate at one or more frequencies, with each frequency
13 corresponding to a different channel. It should be noted that channels may be
14 defined alternatively (and/or additionally) using a mechanism other than
15 frequency, such as a code, a time slot, some combination thereof, and so forth.

16 As described above, each respective RF part 610(1, 2 ... N) is coupled to a
17 respective BB unit 608(1, 2 ... N). Also, each respective MAC 604(1, 2 ... N) is
18 associated with a respective BB unit 608(1, 2 ... N). Although not so illustrated in
19 FIG. 6 or required, each respective MAC 604 and its associated respective BB unit
20 608 may be located on individual respective electronic cards. The respective RF
21 part 610 to which each respective BB unit 608 is coupled may also be located on
22 the individual respective electronic cards. In a described implementation, each
23 respective MAC 604 and its associated respective BB unit 608 may be associated
24 with a different respective access point, such as access points 402(1, 2 ... N) (of
25 FIG. 4). Each respective RF part 610, along with at least part of beamformer 612

1 and/or antenna array 208, and each respective communication beam 202 may also
2 correspond to the different respective access points 402.

3 MACs 604 are adapted to control access to the media that is provided, at
4 least partially, by BB units 608. In this case, the media corresponds to the signals
5 transmitted and/or received via communication beams 202 (of FIGS. 2 and 3).
6 These signals may be analog, digital, and so forth. In a described implementation,
7 such digital signals comprise one or more packets.

8 In a packet-based environment, a packet arriving at access station 102 via a
9 particular communication beam 202(w) from a particular remote client 104(w) (of
10 FIGS. 1 and 2) is received using beamformer 612 and antenna array 208. The
11 packet is processed using a particular RF part 610(w) and a particular
12 corresponding BB unit 608(w). The packet is then forwarded from BB unit
13 608(w) to a particular associated MAC 604(w), which permits the packet to be
14 placed on Ethernet backbone 204 (of FIG. 2) by Ethernet switch/router 602.
15 Packets arriving at access station 102 via Ethernet switch/router 602 are eventually
16 transmitted to remote client 104(w) via communication beam 202(w) in an
17 oppositely traversed path.

18 The transmission and reception of packets via communication beams 202,
19 as well as the forwarding of packets within access station 102, may be controlled
20 at least partially by MACs 604. It should be noted that a packet may actually be
21 received by more than one communication beam 202 and BB unit 608/MAC 604
22 pair. Based on the destination address, one MAC 604 selects the packet and the
23 other MACs 604 discard it.

24 In a typical MAC-baseband environment, a MAC controls its associated
25 baseband circuitry using input solely from its associated baseband circuitry. For

1 example, if baseband circuitry indicates to its associated MAC that it is receiving a
2 packet, then the associated MAC does not ask the baseband circuitry to transmit a
3 packet, which can jeopardize the integrity of the packet being received.

4 With (i) co-located access points 402 (e.g., as in FIG. 4) and/or (ii) co-
5 located pairs of MACs 604 and associated BB units 608, (i) a given first access
6 point 402(x) and/or (ii) a given first MAC 604(x)/BB unit 608(x) pair are
7 (possibly) unaware of the condition or state (e.g., transmitting, receiving, idle, etc.)
8 of (i) a second access point 402(y) and/or (ii) a second MAC 604(y)/BB unit
9 608(y) pair, and vice versa. As a result, absent additional control/logic, a packet
10 being received by (i) the given first access point 402(x) and/or (ii) the given first
11 MAC 604(x)/BB unit 608(x) pair can be thrashed (e.g., altered, destroyed,
12 interfered with, rendered unusable for its intended purpose, etc.) by a transmission
13 from (i) the second access point 402(y) and/or (ii) the second MAC 604(y)/BB
14 unit 608(y) pair.

15 This thrashing may occur even though the packet reception and the packet
16 transmission are effectuated using different communication beams 202(x) and
17 202(y), respectively, when the reception and transmission occur on the same
18 channel (or adjacent or otherwise sufficiently proximate channels with imprecise
19 channel boundaries). In other words, an incoming packet reception via a
20 communication beam 202(x) can be rendered unsuccessful by an outgoing packet
21 transmission via a communication beam 202(y) that occurs on the same channel
22 (or adjacent or otherwise sufficiently proximate channels with imprecise channel
23 boundaries) and is temporally overlapping.

24 As described above, MAC coordinator logic 606 is coupled to both of
25 multiple BB units 608(1, 2 ... N) and multiple MACs 604(1, 2 ... N). In a

described implementation, MAC coordinator logic 606 is configured to prevent MACs 604(1, 2 ... N) from causing a transmission if at least one and optionally if any of BB units 608(1, 2 ... N) are receiving. For example, if BB unit 608(2) indicates that it is receiving a packet, MAC coordinator logic 606 instructs MACs 604(1, 2 ... N) so as to restrain them from causing a packet transmission during the packet reception. Factors that can modify, tune, tweak, extend, etc. this packet transmission restraint are provided further below. As an example, the MACs of MACs 604(1, 3 ... N) that enable transmissions on a different channel or channels from that of BB unit 608(2) may not be restrained.

More specifically, each BB unit of BB units 608(1, 2 ... N) forwards a receive indicator ("Rcv. Indicator" in FIG. 6) to MAC coordinator logic 606. MAC coordinator logic 606 is thus able to monitor BB units 608(1, 2 ... N). MAC coordinator logic 606 analyzes the receive indicators to produce a constructive receive indicator ("C-Rcv. Indicator" in FIG. 6). This constructive receive indicator is provided to each MAC of MACs 604(1, 2 ... N).

In a described implementation, each BB unit 608(z) of BB units 608(1, 2 ... N) forwards a receive indicator that reflects whether/when BB unit 608(z) is currently receiving a signal. Optionally, not physically forwarding an indicator may constitute a receive indicator that reflects that no signal is being received. After processing the different receive indicators, MAC coordinator logic 606 forwards the same constructive receive indicator to each MAC of MACs 604(1, 2 ... N) based on multiple, and possibly all, receive indicators. As alluded to above, employing different factors, for example, may result in MAC coordinator logic 606 providing different constructive receive indicators to at least different subsets of MACs of MACs 604(1, 2 ... N).

1 The receive indicators forwarded to MAC coordinator logic 606 from BB
2 units 608(1, 2 ... N) may be comprised of any one or more different indications
3 from BB units 608(1, 2 ... N). For example, the receive indicators may comprise
4 clear channel assessment (CCA) or busy/non-busy indications. Alternatively, the
5 receive indicators may comprise indications of signal reception based on energy
6 signals, cross-correlation signals, data signals, other transmit and/or control
7 signals, some combination thereof, and so forth. Furthermore, a receive indicator
8 may comprise an analog or digital indication (of one or more bits), the driving of
9 one or more lines, the presentation of one or more messages, some combination
10 thereof, and so forth.

11 In a described implementation, MAC coordinator logic 606 accepts the
12 receive indicators from BB units 608(1, 2 ... N) and combines them in some
13 manner to produce the constructive receive indicator(s). For example, MAC
14 coordinator logic 606 may "OR" the receive indicators together to produce the
15 constructive receive indicator. Consequently, if any receive indicator from BB
16 units 608(1, 2 ... N) indicates that a BB unit is receiving a signal, then the
17 constructive receive indicator indicates to each MAC of MACs 604(1, 2 ... N) that
18 a reception is occurring on some communication beam 202 (and/or access point
19 402) of access station 102. As a result, the MACs of MACs 604(1, 2 ... N) that
20 are provided such an affirmative constructive receive indicator do not cause their
21 respective associated BB units of BB units 608(1, 2 ... N) to transmit.

22 The constructive receive indicators provided from MAC coordinator logic 606 to
23 MACs 604(1, 2 ... N) may be comprised of any one or more different indications
24 interpretable by MACs 604(1, 2 ... N). For example, the constructive receive
25 indicators may comprise an indication for one or more predetermined inputs, such

1 as a CCA or busy/non-busy input, of MACs 604(1, 2 ... N). Alternatively, the
2 constructive receive indicators may be input to a different type of do-not-transmit
3 input, a specially-designed input, a message-capable input, some combination
4 thereof, and so forth. Furthermore, a constructive receive indicator may comprise
5 an analog or digital indication (of one or more bits), the driving of one or more
6 lines, the presentation of one or more messages, some combination thereof, and so
7 forth.

8 FIG. 7 is a flow diagram 700 that illustrates an exemplary method for using
9 MAC coordinator logic with multiple MACs and associated multiple BB units.
10 Flow diagram 700 includes three (3) blocks 702-706. The actions of flow diagram
11 700 may be performed, for example, by MAC coordination logic of an access
12 station (e.g., by MAC coordinator logic 606 of access station 102 of FIG. 6).

13 At block 702, indicators acquired from multiple BB units are monitored.
14 For example, multiple receive indicators that are accepted at MAC coordinator
15 logic 606 from multiple BB units 608(1, 2 ... N) are monitored. At block 704, it is
16 determined whether an affirmative signal reception indicator from a BB unit is
17 detected. For example, of the multiple receive indicators accepted at MAC
18 coordinator logic 606, MAC coordinator logic 606 determines whether at least one
19 receive indicator is detected to indicate that the originating BB unit(s) 608 is(are)
20 receiving a signal. As described above, if a MAC 604 and associated BB unit 608
21 transmit a signal on the same channel as that of a signal being received (e.g., by a
22 different MAC 604/BB unit 608 pair) during that signal reception, the signal being
23 received may be thrashed.

24 If no indicator is determined to affirmatively indicate that a signal is being
25 received (at block 704), the monitoring (of block 702) is continued. For example,

1 as long as MAC coordinator logic 606 fails to detect a signal reception via the
2 receive indicators, MAC coordinator logic 606 continues to monitor the receive
3 indicators from BB units 608(1, 2 ... N). If, on the other hand, an affirmative
4 signal reception indicator from a BB unit has been detected (at block 704), then at
5 block 706 instruction(s) are provided to multiple MACs that are associated with
6 the multiple BB units to restrain signal transmission therefrom. For example, if
7 MAC coordinator logic 606 detects (e.g., through a logical "OR" operation) that at
8 least one receive indicator indicates that a signal reception is occurring, then MAC
9 coordinator logic 606 provides a constructive receive indicator to MACs 604(1, 2
10 ... N) that affirmatively indicates a signal reception is occurring in order to
11 restrain them from initiating or otherwise causing a signal transmission.

12 FIG. 8 illustrates another exemplary access station 102A that includes
13 multiple components such as MACs 604, BB units 608, and MAC coordinator
14 logic 606. Exemplary access station 102A includes thirteen MACs 604(1, 2 ...
15 13) and thirteen BB units 608(1, 2 ... 13) that are associated respectively
16 therewith. Thirteen BB units 608(1, 2 ... 13) and thirteen MACs 604(1, 2 ... 13)
17 are utilized in access station 102A to comport with the efficiently usable
18 communication beams 202(0 ... 6) and 202(10 ... 15) of the exemplary set of
19 communication beams of FIG. 3.

20 However, the elements of FIG. 8 and the description thereof is applicable to
21 access stations 102 with more than or fewer than thirteen MACs 604 and BB units
22 608. Also, although not so illustrated, exemplary access station 102A may include
23 other optional aspects of an access station (e.g., those aspects illustrated in FIG. 6
24 for access station 102).

1 As illustrated, BB units 608(1, 2 ... 13) are capable of communicating with
2 MACs 604(1, 2 ... 13), and vice versa, directly or indirectly without using MAC
3 coordinator logic 606. Specifically, control and/or data may be transferred
4 therebetween. Such control/data information may include, for example, data
5 packets for wireless communication on communication beams 202 (of FIGS. 2 and
6 3), carrier sense multiple access/collision avoidance (CSMA/CA) type
7 information, and so forth.

8 In a described implementation, BB units 608(1, 2 ... 13) forward receive
9 indicators (1, 2 ... 13) to MAC coordinator logic 606. MAC coordinator logic 606
10 includes receive indicators combiner 810. Receive indicators combiner 810 may
11 be comprised of one or more of program coding, a field-programmable gate array,
12 discrete logic gates, and so forth. In other words, receive indicators combiner 810
13 may be comprised of hardware, software, firmware, some combination thereof,
14 and so forth.

15 Receive indicators combiner 810 combines receive indicators (1, 2 ... 13)
16 in some manner to produce constructive receive indicators (1, 2 ... 13). For
17 example, receive indicators (1, 2 ... 13) may be combined using some
18 coordination functionality, such as a logical "OR" functionality. In a described
19 implementation, such logical "OR" functionality ensures that if any one or more
20 receive indicators of receive indicators (1, 2 ... 13) is indicating that a signal is
21 being received, then the associated constructive receive indicators of constructive
22 receive indicators (1, 2 ... 13) also indicate that a signal is being received.

23 These constructive receive indicators (1, 2 ... 13) are provided to MACs
24 604(1, 2 ... 13), respectively, so that MACs 604(1, 2 ... 13) do not cause BB units
25 608(1, 2 ... 13) to transmit a signal while another signal is being received. As

described further below, the BB units of BB units 608(1, 2 ... 13) and the MACs of MACs 604(1, 2 ... 13) may be segmented or grouped by a characteristic and/or state, such as by wireless communications channel. When segmented or grouped, a constructive receive indicator of a given segment or group indicates to a MAC that a signal is being received and that no signal should therefore be transmitted when any receive indicator of that given segment or group indicates that a signal is being received (or when multiple receive indicators of that given segment or group indicate that multiple signals are being received).

As noted above, MAC coordinator logic 606 (and signal transmission/reception coordination logic 404 (of FIG. 4)) may be modified, tweaked, expanded, etc. based on any one or more of many factors. FIG. 8 illustrates some of these factors. For example, FIG. 8 includes channel assignment information 802, receive indicator enable information 804, timer logic 816, and scanning logic 812. Channel assignment information 802, receive indicator enable information 804, timer logic 816, and/or scanning logic 812 may be part of MAC coordinator logic 606 or another part of access station 102A.

Channel assignment information 802 enables receive indicators (1, 2 ... 13) to be combined by receive indicators combiner 810 on a per-channel basis. As a result, constructive receive indicators (1, 2 ... 13) restrain signal transmissions from MAC 604/BB unit 608 pairs when a signal reception is occurring on the same channel, even if by a different MAC 604/BB unit 608 pair. A downlinked packet that is transmitted on one channel while an uplinked packet is being received on another channel does not usually cause the uplinked packet to be thrashed (as long as the two channels are sufficiently well-defined or otherwise separated). On the other hand, a downlinked packet that is transmitted on a

1 channel while an uplinked packet is being received on the same channel does
2 usually cause the uplinked packet to be thrashed, even if the transmission and
3 reception occur using different communication beams 202 (of FIGS. 2 and 3).

4 Channel assignment information 802 may be implemented as, for example,
5 a vector that relates each MAC 604 and associated BB unit 608 to one of two or
6 more channels. Hence, prior to combination using receive indicators combiner
7 810, each respective receive indicator of receive indicators (1, 2 ... 13) can be
8 mapped to a channel segmentation or grouping based on a wireless
9 communication channel used by a corresponding MAC 604/BB unit 608 pair.

10 Receive indicator enable information 804 provides information for receive
11 indicators combiner 810 that stipulates which receive indicators of receive
12 indicators (1, 2 ... 13) are to be used in a combination operation to produce the
13 constructive receive indicators of constructive receive indicators (1, 2 ... 13).
14 Thus, certain receive indicators may be excluded from the combination operation
15 for one or more reasons. For example, a grouping can be arbitrary, can be based
16 on the presence of an overlapping subnet, etc.; each group may therefore be
17 treated differently by or for a coordination function. Exemplary combination
18 groupings and reasons for exclusion are described further below. Using receive
19 indicator enable information 804 reduces the likelihood that external channel
20 activity can prevent all transmissions from access station 102.

21 Receive indicator enable information 804 may be implemented as, for
22 example, a masking register 814 that comprises a register with exclusionary bits
23 for masking one or more receive indicators of receive indicators (1, 2 ... 13) from
24 a combination operation of receive indicators combiner 810. In a described
25 implementation, masking register 814 includes thirteen bits that correspond to the

thirteen receive indicators (1, 2 ... 13), which correspond to the thirteen BB units 608(1, 2 ... 13).

Timer logic 816 may be used for one or two (or more) factors. Although only shown once, timer logic 816 may alternatively be implemented multiple times in exemplary access station 102A to account for multiple factors, or one implementation may be capable of handling multiple timer functions. Timer logic 816 includes watchdog timer 808 and optionally watchdog interrupt enable information 806.

For a first factor, timer logic 816 relates to individual receive indicators (1, 2 ... 13). A duration of watchdog timer 808 is set equal to a maximum packet duration (e.g., a maximum-allowed length of a packet). Watchdog timer 808 is started when a particular receive indicator begins indicating that a signal is being received and stopped when the particular receive indicator ceases indicating that the signal is being received. If watchdog timer 808 is not tolled by an indication of signal reception cessation prior to its expiration, then the signal being received is likely to not be intended for access station 102A. In this case, timer logic 816 may indicate that the BB unit 608 corresponding to the particular receive indicator is not to be used in a combination operation.

This combination operation exclusion indication may be effectuated using receive indicator enable information 804 (e.g., by setting a bit in masking register 814). This exclusion may last for a predetermined duration, which may be, for example, a system parameter that is individually configured for a given deployment. It should be noted that expiration of watchdog timer 808 may also occur in other situations. For example, it may also occur when a packet is involved in a collision with one or more temporally overlapping packets, when

1 there is a large interferer emanating an appropriate signal for a sufficiently long
2 duration, and so forth.

3 For a second factor, timer logic 816 relates to constructive receive
4 indicators (1, 2 ... 13) on a per-channel basis. A duration of watchdog timer 808
5 is set with consideration of a temporal threshold beyond which a problem or error
6 should be contemplated to have occurred and hence investigated. Watchdog timer
7 808 is started when a particular constructive receive indicator (or indicators) for a
8 given channel begins indicating that a signal is being received on the given
9 channel and stopped when the particular constructive receive indicator ceases
10 indicating that the signal is being received on the given channel. If watchdog
11 timer 808 is not tolled by an indication of signal reception cessation prior to its
12 expiration, then there is a likelihood that an error has occurred.

13 Watchdog interrupt enable information 806 is used for this second factor,
14 and it stipulates which channel(s) (and thus which constructive receive indicators)
15 are enabled for interruption. If watchdog timer 808 expires and the given channel
16 is enabled in accordance with watchdog interrupt enable information 806, an
17 interrupt is generated and provided to MAC coordinator logic 606 or another
18 component of access station 102A. MAC coordinator logic 606 or the other
19 component is then charged with investigating the ongoing affirmative constructive
20 receive indicator and/or of notifying a user/operator to do so.

21 Scanning logic 812 may act independently or interactively with any one or
22 more of channel assignment information 802, receive indicator enable information
23 804, and timer logic 816. For example, scanning logic 816 may scan across
24 communication beams 202 using different channels on receive to detect which
25 channel or channels have the least or lowest interference levels. This scanning

1 may occur once, periodically, continuously, and so forth. A channel assignment
2 vector or similar for channel assignment information 802 may be configured
3 responsive to such scanning and interference determinations of scanning logic
4 812.

5 As another example, scanning logic 812 may scan across communication
6 beams 202 to detect the presence of other access points (e.g., non-co-located
7 access points) that are causing interference on a regular or constant basis. The
8 existence of an access point may be inferred by receiving a basic service set
9 identifier (BSSID) being broadcast by another access point. When another access
10 point is detected within a coverage area of a particular communication beam 202
11 (e.g., when an overlapping subnet is detected), scanning logic 812 may interact
12 with receive indicator enable information 804 to mask out a corresponding receive
13 indicator from a BB unit 608 that corresponds to the particular communication
14 beam 202. As a result, frequent receptions from the overlapping subnet (e.g.,
15 another access station having an overlapping coverage area) do not constantly
16 prevent BB unit 608/MAC 604 pairs on the same channel from transmitting. Such
17 a configuration or feature may be enabled by observing long term statistics of
18 overlapping subnet traffic, through explicit communication between different
19 various subnets or their network management entities, and so forth.

20 In an exemplary implementation, access station 102A may be configured as
21 follows: The receive indicators (1, 2 ... 13) correspond to the state of the CCA
22 output as detected by BB units 608(1, 2 ... 13), and constructive receive indicators
23 (1, 2 ... 13) correspond to the state of the CCA input to MACs 604(1, 2 ... 13).
24 Based on the values for receive indicators (1, 2 ... 13), channel assignment
25 information 802, and receive indicator enable information 804, MAC coordinator

1 logic 606 determines the constructive receive indicators (1, 2 ... 13) for each RF
2 part 610 (of FIG. 6) (as provided via MACs 604, BB units 608, etc).

3 Continuing with this exemplary implementation, MAC coordinator logic
4 606 operates as follows:

5 An indicator "channel_wide_busy" for each channel is
6 defined, where channel_wide_busy is affirmative (e.g., active) if:

- 7 • the receive indicator from any BB units operating on
8 that channel indicates that a signal is being received,
9 excluding those BB units whose receive indicator enable
10 information is not set (e.g., in masking register 814).

11 MAC coordinator logic 606 sets the constructive receive
12 indicator for a particular MAC 604/BB unit 608 pair to affirmative
13 (e.g., busy) if:

- 14 • the receive indicator for that BB unit 608 indicates
15 affirmative (e.g., busy); or
16 • channel_wide_busy for the channel of this particular
17 MAC 604/BB unit 608 pair is affirmative (e.g., active).

18 FIG. 9 is a flow diagram 900 that illustrates another exemplary method for
19 using MAC coordinator logic with multiple MACs and associated multiple BB
20 units. Flow diagram 900 includes six (6) blocks 902-912. The actions of flow
21 diagram 900 may be performed, for example, by MAC coordination logic of an
22 access station (e.g., by MAC coordinator logic 606 of access station 102A of FIG.
23 8).

24 At block 902, multiple respective receive indicators are accepted from
25 respective multiple BB units. For example, receive indicators (1, 2 ... 13) may be

1 accepted from BB units 608(1, 2 ... 13) at MAC coordinator logic 606. At block
2 904, non-enabled receive indicators of the multiple respective receive indicators
3 are masked. For example, one or more of receive indicators (1, 2 ... 13) may be
4 masked in accordance with receive indicator enable information 804 using
5 masking register 814. The non-masked receive indicators are therefore enabled
6 receive indicators.

7 At block 906, enabled receive indicators are mapped into channel-based
8 groups. For example, those receive indicators of receive indicators (1, 2 ... 13)
9 that are not masked out by masking register 814, may be segmented by channel in
10 accordance with channel assignment information 802. It should be noted that the
11 actions of blocks 904 and 906 in particular may be performed sequentially or
12 partially, substantially, or completely simultaneously with each other. Once the
13 enabled receive indicators are grouped, production of constructive receive
14 indicators may be effectuated by group on a per-channel basis. Thus, as shown in
15 FIG. 9, the actions of blocks 908 and 910 may be performed for as many groups
16 (e.g., two or more) as there are channels.

17 At block 908, receive indicators of a channel-based group are combined
18 into a channel-based receive indicator. For example, receive indicators of receive
19 indicators (1, 2 ... 13) that are enabled and that correspond to a single channel
20 may be logically "ORed" together. At block 910, multiple respective constructive
21 receive indicators are produced using the channel-based receive indicator and a
22 respective receive indicator. For example, for each of multiple MAC 604/BB unit
23 608 pairs, a respective constructive receive indicator of constructive receive
24 indicators (1, 2 ... 13) is produced responsive to the corresponding respective
25

1 receive indicator of receive indicators (1, 2 ... 13) and the channel-based receive
2 indicator.

3 Thus, each respective constructive receive indicator of constructive receive
4 indicators (1, 2 ... 13) affirmatively indicates that a signal is being received to
5 MACs 604(1, 2 ... 13) if an associated respective BB unit 608(1, 2 ... 13)
6 forwards an affirmative receive indicator (1, 2 ... 13) or any respective BB unit
7 608(1, 2 ... 13) mapped to the same channel forwards an affirmative receive
8 indicator (1, 2 ... 13). The actions of blocks 908 and 910 for each channel-based
9 group may be performed sequentially or partially, substantially, or completely
10 simultaneously with each other.

11 At block 912, the multiple respective constructive receive indicators are
12 provided to multiple respective MACs. For example, constructive receive
13 indicators (1, 2 ... 13) may be provided to MACs 604(1, 2 ... 13) from MAC
14 coordinator logic 606. As indicated by the initial and final flow arrows in flow
15 diagram 900 (as well as those of flow diagrams 500 and 700 of FIGS. 5 and 7,
16 respectively), the illustrated methods may repeat, continue, be part of a larger
17 method, some combination thereof, and so forth.

18 FIG. 10 illustrates an exemplary implementation of and environment 1000
19 for signal transmission/reception coordination logic 404. Signal
20 transmission/reception coordination logic 404 accepts as inputs receive
21 information (1, 2 ... N) and produces as outputs combined receive information (1,
22 2 ... K). The number "N" of receive information inputs may not equal the number
23 "K" of combined receive information outputs.

24 In a described implementation, signal transmission/reception coordination
25 logic 404 includes receive information combiner 1002 and receive information

1 selector 1004. Receive information combiner 1002 applies a signal coordination
2 function to the receive information (1, 2 ... N) to produce the combined receive
3 information (1, 2 ... K). The combined receive information (1, 2 ... K) may be
4 utilized to ascertain signal reception and restrain signal transmission.

5 The combined receive information (1, 2 ... K) may optionally be produced
6 with regard to receive information selector 1004. Receive information selector
7 1004 enables a selectivity to be applied to the combining of the receive
8 information (1, 2 ... N). Factors controlling this receive information selectivity
9 are generally represented by general selectivity 1006. Receive information
10 selector 1004 instructs receive information combiner 1002 as to what receive
11 information (1, 2 ... N) is to be combined or excluded and into which groups or
12 segments.

13 In a more-specific implementation with reference to FIGS. 6 and 8, signal
14 transmission/reception coordination logic 404 may be realized as MAC
15 coordinator logic 606. Thus, receive information (1, 2 ... N) may correspond to
16 receive indicators (1, 2 ... 13), and combined receive information (1, 2 ... K) may
17 correspond to constructive receive indicators (1, 2 ... 13). Similarly, the
18 functionality describe herein above with reference to channel assignment
19 information 802, receive indicator enable information 804/masking register 814,
20 scanning logic 812, etc. is exemplary receive information selectivity control for
21 receive information selector 1004.

22 Continuing with FIG. 10, another control factor for receive information
23 selector 1004 is provided by channel selectivity 1008. Channel selectivity 1008,
24 via receive information selector 1004, enables receive information combiner 1002
25

1 to selectively combine respective receive information (1, 2 ... N) according to
2 respective channel groups.

3 Another control factor for receive information selector 1004 is provided by
4 overlapping subnet selectivity 1010. Receptions from other (undesired) access
5 stations/subnets are identified so that they may be disregarded. Specifically, if a
6 communication beam of a given access station is receiving a signal from another
7 (undesired) access station/subnet, then the receive information corresponding to
8 that communication beam is de-selected by receive information selector 1004 at
9 receive information combiner 1002 for the relevant coordination function so as not
10 to affect the combined receive information (1, 2 ... K). Consequently,
11 transmissions at a given access station are not restrained by signals that are
12 received thereat from other access stations/overlapping subnets.

13 Still yet another control factor for receive information selector 1004 is
14 provided by packet content selectivity 1012. The content of one or more received
15 packets are used to select which and/or how receive information (1, 2 ... N) is
16 combined by receive information combiner 1002. For example, a destination
17 address (e.g., a MAC address) of the received packet is compared to a destination
18 address (e.g., for a singular access point) or a set of destination addresses (e.g., for
19 multiple co-located access points) of the receiving access point.

20 If the destination address of the received packet is equivalent to (one of) the
21 destination address(es) of the receiving access point (access station), then the
22 receive information for the received packet is selected for inclusion/consideration
23 by receive information selector 1004 at receive information combiner 1002. If
24 not, then the receive information for the received packet is excluded for
25 consideration by receive information selector 1004 at receive information

1 combiner 1002. More generally for signal transmission/reception coordination
2 logic 404, a coordination function may be applied to signal communication
3 information in order to produce combined signal communication information that
4 is utilized to coordinate signal transmission and reception. It should be noted that
5 the destination address may be compared for an equivalency determination after a
6 portion of the packet has been received but before the entirety of the packet has
7 been received (i.e., before reception is complete).

8 FIG. 11 illustrates a first exemplary multiple access station environment
9 1100 that includes signal transmission/reception coordination logic 404. Multiple
10 access station environment 1100 includes two or more access stations 102. Each
11 access station 102 may be in wireless communication with at least one remote
12 client 104 via an antenna, two or more antennas, or an antenna array 208.

13 As illustrated, an access station 102a is in wireless communication with
14 remote clients 104a(1), 104a(2) ... 104a(N) via wireless communications or
15 communication links 106a(1), 106a(2) ... 106a(N), respectively. Access station
16 102b is in wireless communication with remote clients 104b(1), 104b(2) ...
17 104b(N) via wireless communications or communication links 106b(1), 106b(2)
18 ... 106b(N), respectively.

19 Each access station 102a and 102b is coupled to signal
20 transmission/reception coordination logic 404 via a link 1102. Specifically, access
21 station 102a is coupled to signal transmission/reception coordination logic 404 via
22 link 1102a, and access station 102b is coupled to signal transmission/reception
23 coordination logic 404 via link 1102b.

24 Links 1102a and 1102b are likely wired links, but they may instead be
25 wireless links. Although signal transmission/reception coordination logic 404 is

1 shown separately from both access stations 102a and 102b, signal
2 transmission/reception coordination logic 404 may alternatively be co-located at
3 and/or located within an access station 102a or 102b. Additionally, access station
4 102a and/or 102b may also include internal signal transmission/reception
5 coordination logic 404.

6 Signal transmission/reception coordination logic 404 as illustrated in FIG.
7 11 enables signal transmission/reception coordination across multiple access
8 stations 102 to prevent or at least reduce interference. For example, there is
9 potential interference if access station 102a transmits wireless communication
10 106a(N) to remote client 104a(N) on a particular channel at the same time access
11 station 102b transmits wireless communication 106b(1) to remote client 104b(1)
12 on the same particular channel, especially because of the proximity of remote
13 client 104a(N) to remote client 104b(1). To eliminate this particular interference
14 and ameliorate the overall network interference levels, signal
15 transmission/reception coordination logic 404 restrains access station 102b from
16 transmitting communication signal 106b(1) to remote client 104b(1) when access
17 station 102a is transmitting communication signal 106a(N) to remote client
18 104a(N), and vice versa.

19 The above-described inter-access station 102 restraining may include, for
20 example, situations in which coordination logic 404 restrains access station 102b
21 from transmitting to client 104b(1) when client 104a(N) is awaiting a short-term
22 (e.g., an immediate) response to a frame that client 104a(N) transmitted to access
23 station 102a in the recent past. More generally, an implementation may entail
24 restraining transmission from an access point when another access point (e.g., that
25 is part of the same or a different access station 102) that is operating on the same

1 or a different channel (e.g., that is adjacent or otherwise) is expecting an
2 immediate response to a frame that was transmitted by it. For example, this type
3 of transmission restraint may be performed if the configuration of the wireless
4 system is such that transmission by the access point interferes with the reception
5 of the other access point.

6 FIG. 12 illustrates exemplary multiple access station environment 1100 that
7 includes MAC coordinator logic 606. MAC coordinator logic 606 of FIG. 12
8 logically functions like MAC coordinator logic 606 of FIG. 6 and/or FIG. 8, but it
9 is distributed spatially as indicated by link 1202. Link 1202 is likely a wired link,
10 but it may instead be a wireless link.

11 As illustrated, a respective emanation apparatus 1204 is coupled to a
12 respective RF part 610. Specifically, RF part 610(1) is coupled to emanation
13 apparatus 1204(1), RF part 610(2) is coupled to emanation apparatus 1204(2), and
14 RF part 610(N) is coupled to emanation apparatus 1204(N). Each emanation
15 apparatus 1204 includes an antenna or antenna array 208 and optionally a
16 beamformer 612.

17 At least each RF part 610 and emanation apparatus 1204 pair may
18 correspond to an individual access station 102 and/or access point 402. In a
19 described implementation, at least one RF part 610 and emanation apparatus 1204
20 pair is non-co-located with at least one other RF part 610 and emanation apparatus
21 1204 pair. At least some of the individual access station(s) 102 and/or access
22 point(s) 402 have at least partly overlapping coverage areas.

23 Besides being distributed, MAC coordinator logic 606 may operate
24 analogously to a MAC coordinator logic 606 for a single access station 102
25 environment. In other words, MAC coordinator logic 606 accepts as inputs

1 multiple receive indicators from BB units 608(1, 2 ... N) and produces as outputs
2 multiple constructive receive indicators for associated respective MACs 604(1, 2
3 ... K). With a distributed MAC coordinator logic 606 that is coupled by link 1202
4 between or among two or more access stations 102, the thrashing of packets can
5 be reduced, along with general network interference.

6 In the exemplary multiple access station environment 1100 (of FIGS. 11
7 and 12), as well as other environments, the overall system performance may also
8 be improved by considering other issues beyond local packet thrashing. The
9 selectability of signal transmission/reception coordination logic 404 (e.g., of FIG.
10 10) may entail excluding selected MAC(s) from being provided combined receive
11 information that restrains signal transmissions either consistently or in certain
12 situations. Such excluded MACs may be selected when a MAC has higher
13 downlink bandwidth requirements, when a particular MAC's downlink throughput
14 is otherwise low, when a policy-based decision indicates that downlink
15 communications are more important than uplink communications (e.g., a server is
16 operating), and so forth.

17 FIG. 13 illustrates a second exemplary multiple access station environment
18 1100 that includes signal transmission/reception coordination logic 404. MAC
19 coordinator logic 606 of FIG. 12 is an example of a distributed signal
20 transmission/reception coordination logic 404 at a MAC level that optionally uses
21 MAC primitives. On the other hand, signal transmission/reception coordination
22 logic 404 of FIG. 13 operates at a baseband level.

23 As illustrated, signal transmission/reception coordination logic 404 is
24 distributed across multiple individual access station(s) 102 and/or access point(s)
25 402 that have at least partly overlapping coverage areas. It should be noted,

1 however, that signal transmission/reception coordination logic 404 is shown
2 operating at the baseband level. Signal transmission/reception coordination logic
3 404 accepts as inputs receive information from multiple RF parts 610(1, 2 ... N)
4 and produces as outputs combined receive information for multiple respective BB
5 units 608(1, 2 ... K). Respective BB units 608(1, 2 ... K) provide MAC
6 primitives to respective MACs 604(1, 2 ..., K) based on the combined receive
7 information.

8 In a described implementation for FIG. 13, the receive information
9 comprises at least one received packet that is analyzed by signal
10 transmission/reception coordination logic 404. Implementing signal
11 transmission/reception coordination logic 404 at the baseband layer is typically
12 more complex than implementing it at the MAC layer; however, there is more
13 information and/or flexibility available at the baseband layer, which provides for
14 more options. Furthermore, signal transmission/reception coordination logic 404
15 may be implemented at the baseband layer in a system that utilizes off-the-shelf
16 chips in which MAC and baseband functionality are integrated into a single chip
17 or chips that may not separately expose desired MAC signal(s) (e.g., MAC
18 primitives).

19 Signal transmission/reception coordination logic 404 applies one or more
20 coordination functions to the receive information accepted from RF parts 610(1, 2
21 ... N). The resulting combined receive information is forwarded to BB units
22 608(1, 2 ... K). Based on the combined receive information, respective BB units
23 608(1, 2 ... K) provide MAC primitives to associated respective MACs 604(1, 2 ...,
24 K). The MAC primitives can instruct the MACs 604(1, 2 ... K) with regard to
25

1 whether a signal is being received and/or constructively received by a
2 corresponding RF part 610 and emanation apparatus 1204 pair.

3 The diagrams of FIGS. 1-13 are illustrated as blocks representing features,
4 devices, logic, functions, actions, some combination thereof, and so forth.
5 However, the order and/or layout in which the diagrams are described and/or
6 shown is not intended to be construed as a limitation, and any number of the
7 blocks can be combined, augmented, omitted, and/or re-arranged in any order to
8 implement one or more methods, systems, apparatuses, access stations,
9 arrangements, schemes, approaches, etc. for signal communication coordination.

10 By way of example only, the blocks of FIGS. 1-13 (e.g., the components of
11 FIGS. 2, 4, 6, 8, and 10-13 and/or the actions of FIGS. 5, 7, and 9) may be
12 implemented fully or partially as one or more processors and/or as one or more
13 media. Such processors may be general purpose microprocessors, special-purpose
14 digital signal processors, some combination thereof, and so forth. Such media
15 may be transmission or storage media, volatile or non-volatile memory,
16 programmable or hard-wired coding, some combination thereof, and so forth.
17 Moreover, the media may include processor-executable instructions that one or
18 more associated processors are capable of executing.

19 Furthermore, although the description herein includes references to specific
20 hardware-oriented implementations such as those of FIGS. 2-4, 6, 8 and 10-13 (as
21 well as the exemplary general environment of FIG. 1), the features, logic, devices,
22 and functions thereof as well as the actions of FIGS. 5, 7, and 9 can be
23 implemented in any suitable hardware, software, firmware, or combination thereof
24 and using any suitable coding/logical mechanism(s), wireless protocol
25 paradigm(s), radio frequency technology, and so forth. Additionally, the order in

1 which the multiple blocks for the methods of FIGS. 5, 7, and 9 are illustrated
2 and/or described is not intended to be construed as a limitation and the actions of
3 any number of the described blocks, or portions thereof, can be combined,
4 augmented, omitted, and/or re-arranged in any order to implement one or more
5 methods for signal communication coordination.

6 Although methods, systems, apparatuses, access stations, arrangements,
7 schemes, approaches, and other implementations have been described in language
8 specific to structural and functional features and/or flow diagrams, it is to be
9 understood that the invention defined in the appended claims is not necessarily
10 limited to the specific features or flow diagrams described. Rather, the specific
11 features and flow diagrams are disclosed as exemplary forms of implementing the
12 claimed invention.